Field test results of self-calibrating cryogenic mass flow meter WEKASENSE®

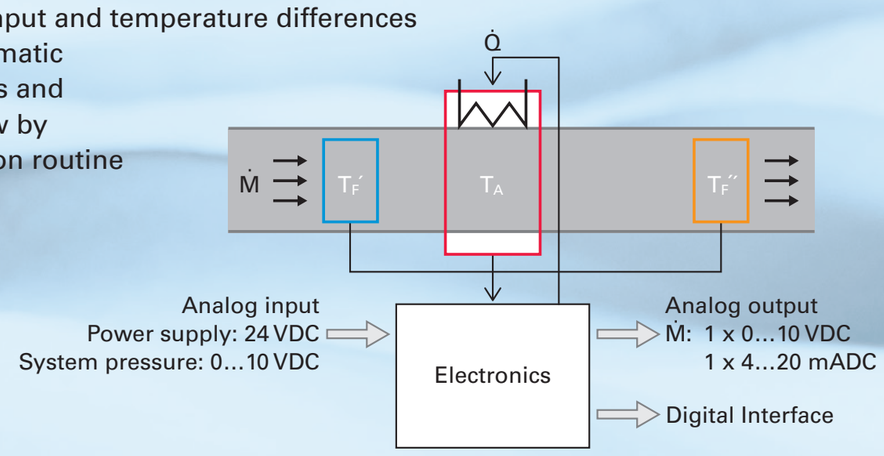
Karlsruhe Institute of Technology

Introduction

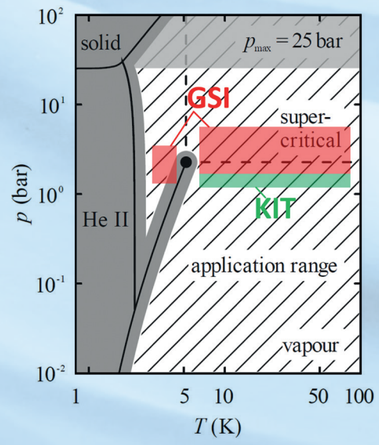
WEKA developed together with Karlsruhe Institute of Technology (KIT) a mass flow meter for cryogenic applications. The sensor is based on a new thermal measurement principle developed and verified by KIT. After successful validation of the self-calibrating capability of the sensor at cryogenic conditions in the TOSKA facility in Karlsruhe, the sensor was installed in several field test applications e.g. at the Helmholtzzentrum für Schwerionenforschung (GSI) in Darmstadt and at the Karlsruhe Institute of Technology (KIT) to perform the cold testing at a Laminar Flow Element (LFE) test bed. The results gained from these field test installations are presented.

Measurement principle and scope of field tests

- Caloric measurement principle *(Grohmann, S. (2014): A new method for flow measurement in cryogenic systems. Cryogenics, vol. 60, March-April 2014, pp. 9–18.)*
- Measurement of heat input and temperature differences
- Compensation of systematic measuring uncertainties and calculation of mass flow by automatic self-calibration routine



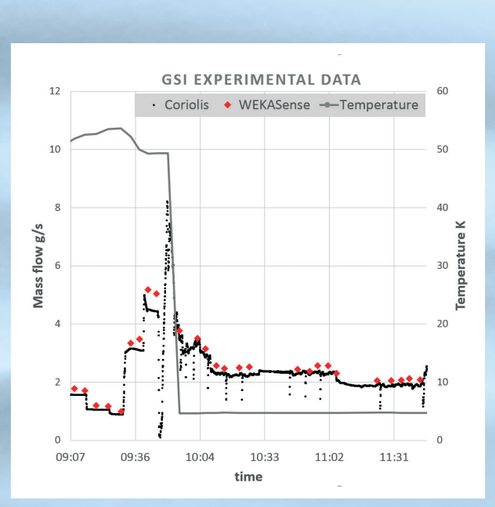
- 3 measurement modes:
  - Self-calibration mode
  - Continuous measurement mode
  - Standby mode (no heat input, only temperature measurement
- Field tests at the GSI were performed to
  - verify the measurement uncertainty in self-calibration mode
  - determine the measurement uncertainty in measurement mode
- Field tests at the KIT were performed to verify the accuracy in measurement mode and functionality



Cryogenic tests at the GSI

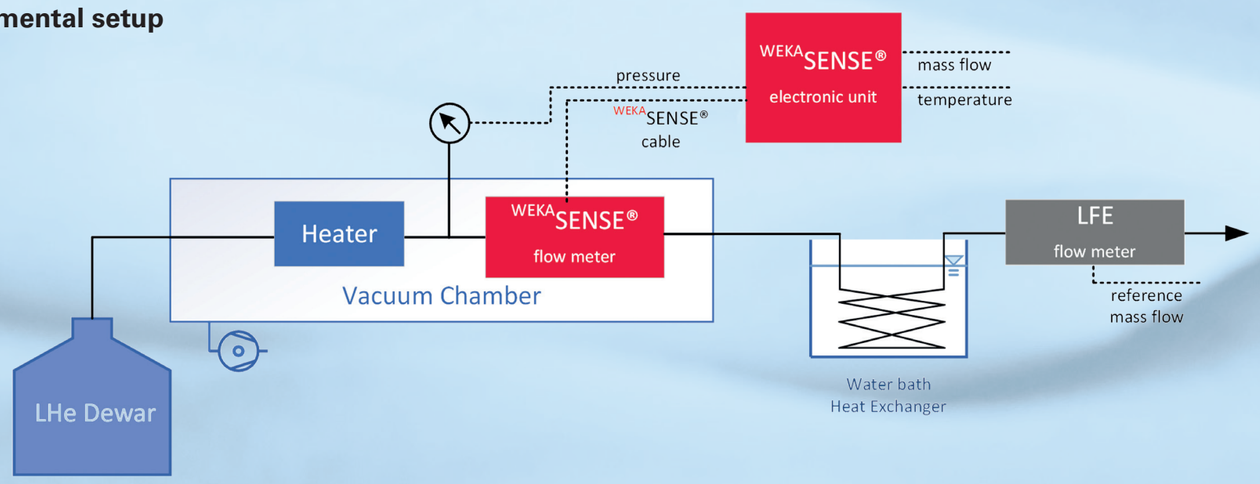
Experimental results

- Experimental proof of functionality in a wide temperature and mass flow range
- Measurements in the range of
  - T: 4.5 K to 290 K
  - p: 1.8 bar to 5 bar
  - ṁ: 1 g/s to 6 g/s
    over 11 days of continuous testing
- Measurements of different mass flow meters were in the expected range

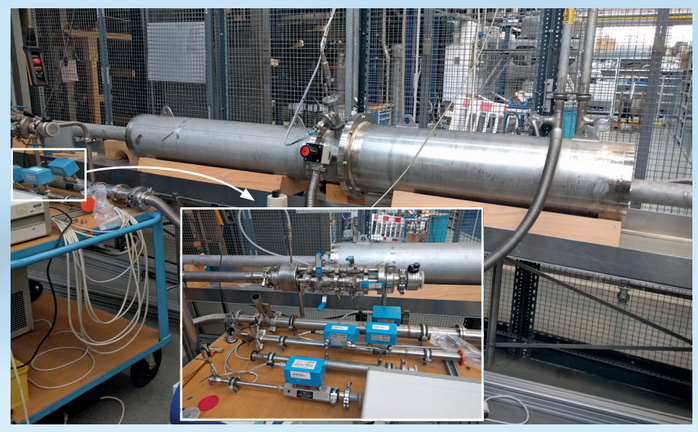


Cryogenic functional tests at the LFE test bed at the KIT

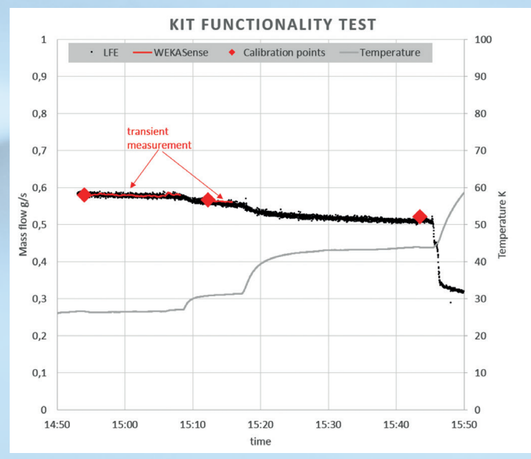
Experimental setup



- Installation in a vacuum chamber with fluid heater
- Fluid flow in the picture: from right to left
- Reference measurements with a Laminar Flow Element flowmeter (marked and highlighted in the picture)
- Measurements in the range of
  - T: 55 K to 45 K
  - p: 1.1 bar
  - m: 0.5 g/s to 1.0 g/s
  - Several days of testing



Experimental results



- Full functionality test with successful checking of all measurement modes
  - Self-calibration mode
  - Continuous measurement mode
  - Standby mode

Process parameters	
Fluid	GHe/LHe not superfluid, not 2-phase
Measurement range	0.2…12 g/s
Temperature range	3 K…100 K
Nominal pressure	PN25
Pressure drop	a few 10 mbar depending on the operating conditions, Bsp. 50 mbar @ 7 g/s, 4.5 K, 5 bar
Temperature increase	a few 10 mK depending on the operating conditions
Measurement accuracy	< 1% of the actual flow rate under stable operating conditions

Summary and Outlook

- Successful proof of functionality and accuracy under cryogenic operating conditions
- Further performance tests are planned at CERN
- Market introduction planned until end of the year 2018 under the product name WEKASENSE®
- Advantages of the measurement principle:
  - High accuracy (uncertainties < 1 % w.r.t. the actual flow rate)
  - In situ calibration under real operating conditions
  - Small operating losses (pressure drop, temperature increase)
  - Minimum space requirement
  - Easy installation and commissioning
  - Integrated temperature measurement

P. Erni, M. Boersch, D. Oertig,
J. Drache, G. Consogno, M. Okanovic
(WEKA AG, Switzerland)

S. Grohmann, A. Janzen[1], A. Ebersoldt,
B. Burger (KIT, Germany)
[1] (Now at general Electric, Germany)

C. Schroeder (GSI, Germany)